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REPORT ON WATER QUALITY IN BOBS LAKE

1972

Ministry
of the
Environment

Ontario

The Honourable
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minister

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deputy minister

REPORT ON WATER QUALITY

in

BOBS LAKE

1972

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PREFACE

The Province of Ontario contains many thousands of beautiful small inland lakes which are most attractive for recreational use. Lakes close to urban areas and accessible by road often receive heavy use in terms of cottage development, camp sites, trailer parks and picnic areas.

A heavy influx of people may subject a lake and it's surrounding environment to great stress. In many cases, developments are carried out on attractive lakes only to find that when this is complete the lake qualities which were initially so appealing have been damaged. The appearance of the shoreline can be marred by construction, fishing ruined by over harvesting or the growth and decay of excessive amounts of algae and weeds. Motor boats introduce noise and petroleum pollution. Inadequate disposal of human wastes can place a great stress on the lake environment.

The accepted custom of having "a place at the lake" continues to apply pressure for more development, giving rise to an even greater expansion of problems.

The Ontario Ministry of the Environment is attempting to bring some of these stress factors under control with a variety of programs. The cottage pollution control program was initiated in 1967 and was expanded in 1970 in order to solve the cottage waste disposal problem in recreational lakes. There are three on-going studies carried out by the Ministry:

1. Evaluation of existing waste disposal systems and enforcement of repairs to those found to be unsatisfactory;

2. Research to improve the knowledge of septic tank operation and effects in shallow soil areas and evaluation of alternative methods of private waste disposal;

3. Evaluation of present water quality in a number of recreational lakes. A totally undeveloped lake near Huntsville was studied in 1972, in order to obtain more information about natural water quality conditions within a Precambrian Lake, which would assist in defining any unnatural conditions encountered in the developed lakes surveyed.

This report on Bobs Lake is one of a series dealing with the water quality aspects of the recreational lakes studies in 1972. As well as defining the present status of water quality in the lakes, the data are meant to provide an historical reference for comparison of conditions at any future time.

SUMMARY

A study to evaluate the water quality in Bobs Lake was carried out during the summer of 1972.

Bobs Lake, located in the counties of Frontenac and Lanark, lies within the Precambrian Shield which is characterized by rolling hills, crystalline bedrock, and shallow overburden. The lake is very irregular in shape, with many separate deep bays joined by narrow shallow channels, giving the lake an exceptionally long shoreline in comparison to its surface area. Approximately 600 cottages are now located on the shores of Bobs Lake, and development of a substantial number of additional cottage lots is presently underway.

The bacteriological quality of Bobs Lake was found to be generally good, with the exceptions of the outflows of Fish and Thompson creeks where enterococcus levels indicated contamination, probably from wild or domestic animals.

The cool denser waters in five of the separate deep basins of Bobs Lake were isolated from one another by an upper layer of less dense warm water by July. The deep waters in four of the basins deteriorated in a consistent stepwise pattern, illustrating clearly the sequences involved in the processes of oxygen depletion and nutrient regeneration. Oxygen depletion in all five basins was evident in June, and grew worse through the summer, until by September up to 12 meters of the bottom water was void of oxygen, rendering these depths unsuitable for fish.

Recycling of nutrients such as phosphorus and nitrogen compounds, through regeneration from the bottom sediments or settled organic debris, was evident in a greater or lesser degree in all five basins. This emphasizes the need to prevent any unnecessary additions of nutrients or organic matter to the lake, such as can occur from inadequate domestic waste disposal systems.

PURPOSE OF THE SURVEYS

The surveys were designed, and tests selected in order to evaluate the present conditions in the lakes with respect to:

-concentration of bacteria

-plant nutrients and algae

-water quality with depth

-inventory of shoreline development

As a result of human activity in the recreational lake environment, some wastes may reach the lake itself and this can lead to either or both of two major types of water quality impairment, microbial contamination and excessive growths of algae and aquatic plants. The two problems can result from a common or different source of pollution, but the consequences of each are quite different.

Microbial contamination by raw or inadequately treated sewage does not significantly change the appearance of the water but poses an immediate public health hazard if the water is used for drinking or swimming. This type of pollution can be remedied by preventing wastes from reaching the lake and water quality will return to satisfactory conditions since most disease causing bacteria do not persist in the lake.

Nutrient enrichment, or eutrophication, results from the addition of plant fertilizers which occur naturally and are also present in virtually all forms of raw or treated human wastes. High concentrations of these fertilizers (plant nutrients), mainly nitrogen and phosphorus, support extensive growths of rooted aquatic plants and of microscopic free-floating plants called algae. Eutrophication greatly affects the lake appearance but generally does not pose a health hazard. Problems due to nutrient enrichment are generally long lasting and may become irreversible.

Changes in water temperature, dissolved oxygen and quality with depth are very important characteristics of a lake and were examined in the surveys.

Aquatic weed beds provide shelter and food for many kinds of fish. Too much growth is undesirable since it can upset the oxygen balance in the lake and can interfere with recreational uses of the lake.

DESIGN OF THE SURVEYS

Timing

Five day bacteriological, chemical and biological surveys were carried out from June 2 to 6, from July 26 to 30, and from September 20 to 22 (except bacteriological).

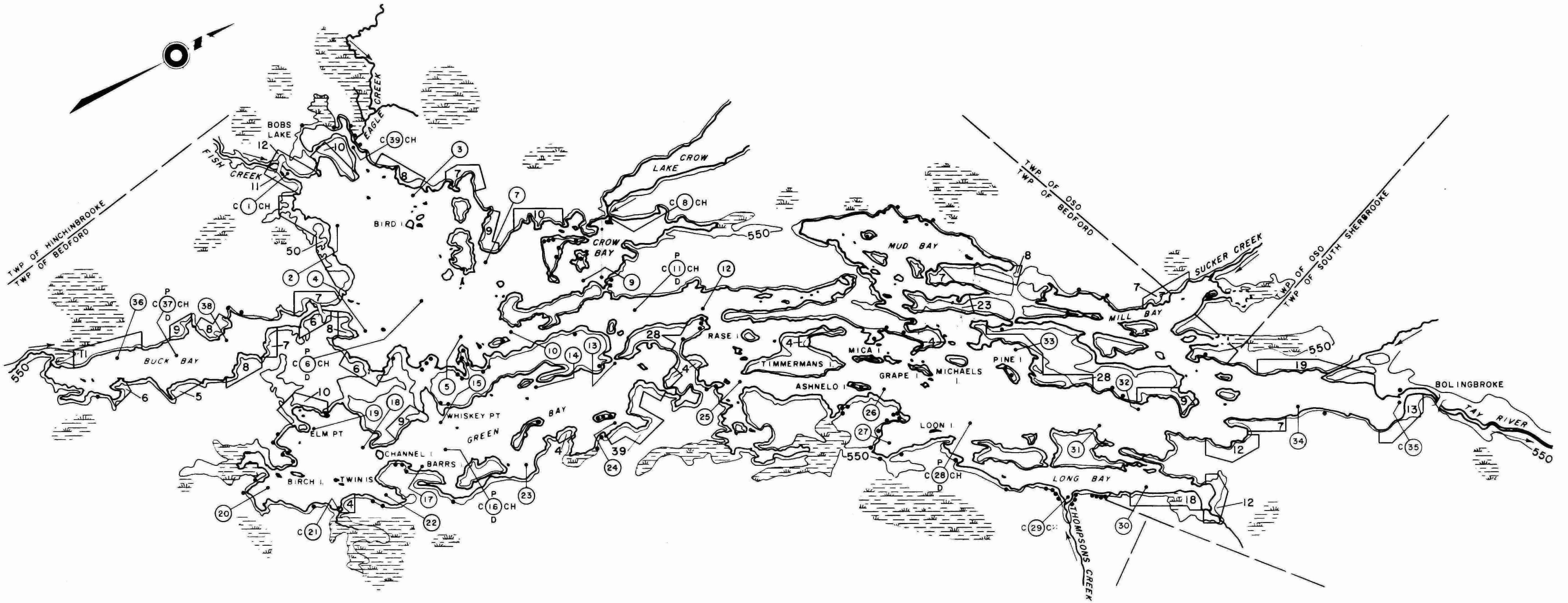
A proper estimation of the bacterial population requires several measurements over a period of time which can then be averaged as a geometric mean. Measurements over 5 consecutive days at each station are regarded as the minimum number which will give reliable bacterial data.

Chemical samples were collected on the first and last days of the surveys at inlet and outlet stations and at the mid-lake stations. Chlorophyll samples were collected each day at the inlet and mid-lake stations.

Selection of Sample Locations

Thirty-nine bacteriological sample sites were established over the whole lake (Figure 1). Chemical samples were collected at four of the inlet stations, the outlet station and at five mid-lake stations. In addition to these surface samples, chemical and bacteriological samples were taken from the bottom water at the mid-lake stations.

FIGURE 1 - COTTAGE DEVELOPMENT AND SAMPLING STATIONS



LEGEND

17 •••• — COTTAGE DEVELOPMENT

550 — CONTOUR INTERVAL

— MARSH

C (8) CH P D — SAMPLING STATION

C - CHEMICAL SAMPLE

P - PROFILE

CH - CHLOROPHYLL SAMPLE

D - DEPTH STATION

1 1/2 0 1 MILES

ENVIRONMENT ONTARIO

RECREATIONAL LAKES PROGRAM

BOBS LAKE

1972 WATER QUALITY SURVEY

SCALE AS SHOWN	
DRAWN BY ARS	DATE JAN., 1973
CHECKED BY	DRAWING Nº 73-8-DE

Field Tests

The variation in temperature and dissolved oxygen values with depth were measured at the three deep water stations with an electronic probe lowered into the lake and water clarity was measured with a Secchi disc, (Figure 2). The pH and conductivity of the samples were measured in the field.

Bacteriological Tests

Three groups of bacteria were determined on each sample: total coliforms, fecal coliforms, fecal streptococci. These organisms are used as "indicators" of fecal contamination. Many diseases common to man can be transmitted by feces, consequently, the probability of occurrence of these diseases is usually highest in areas where the water is contaminated. The total coliforms, fecal coliforms and fecal streptococci organisms are all indigeneous to man and other warm blooded animals and are found in the colon and feces in tremendous numbers. These indicator organisms in the water denote the presence of fecal contamination and hence the risk of disease causing organisms.

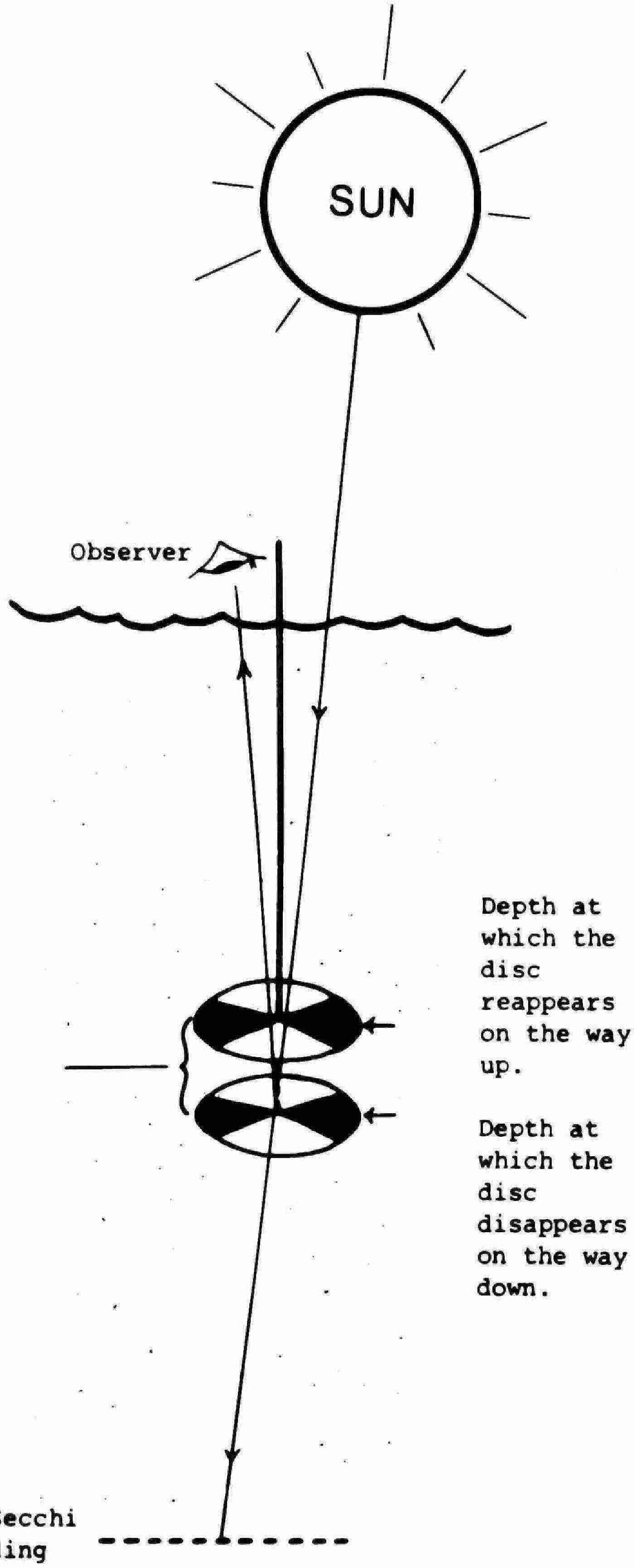
Standard plate count (SPC) determinations were made on some mid-lake stations in order to determine densities of some natural water bacteria. The SPC media will only support the growth of those organisms that do not require special nutrients, oxygen requirements and/or incubation temperatures. The SPC is used as a measure of general bacterial activity.

Chemical Tests

Hardness, alkalinity, chloride, iron and conductivity were measured in order to define the mineral composition of the water. The types of plants and animals which thrive, effects of toxic materials and suitability of the lake for various management techniques depend on the mineral content.

The "Secchi Disc Reading" is obtained by averaging the depth at which a 23cm (9") dia. black and white plate, lowered into the lake just disappears from view and the depth where it reappears as it is pulled up.

Most of the free-floating algae are suspended in the illuminated region between the lake surface and 2 times the Secchi disc reading.



Clear, algae-free lake: Secchi disc readings tend to be greater than 3m (9 feet).

Turbid or algae-rich lake: Secchi disc readings tend to be less than 3m (9 feet).

FIGURE 2: USE OF SECCHI DISC TO DETERMINE WATER CLARITY

Total and soluble phosphorus were measured in the inlet and bottom water samples while total phosphorus only was measured in the mid-lake and outlet surface samples. Soluble phosphorus concentrations are used mainly to substantiate various interpretations of the total phosphorus content.

The total Kjeldahl nitrogen is essentially the amount of nitrogen contained in organic material. It was measured in all of the chemical samples. The soluble forms of nitorgen, ammonia, nitrite and nitrate were measured in the inlet and bottom water samples. They are particularly important in bottom waters since nitrogen may be regenerated from decaying organic matter in these forms.

Chlorophyll a concentrations are an indication of the amount of algae in the water. The live algae are confined mainly to the lighted surface waters which extend down to a depth of about twice the Secchi disc reading. The chlorophyll samples were collected by raising the samples bottle through the depth of this illuminated zone as it filled. The sample was then representative of the average number of algae through the illuminated depth of the surface waters.

DESCRIPTION OF BOBS LAKE AREA

Lake and Soil Characteristics

Bobs Lake is located in Bedford and Sherbrooke townships in the counties of Frontenac and Lanark respectively, approximately 16 kilometers (10 miles) east of Westport.

The lake lies within the Precambrian Shield area which is characterized by rolling hills, crystalline bedrock and a shallow overburden with the exception of some localized glacial deposits. The shoreline is generally moderately to steeply sloping with a moderate to heavy mixed forest.

There are two soil types other than local marsh areas, surrounding Bobs Lake. The lake is almost entirely surrounded by the Monteagle sandy loam - rock complex with the exception of small scattered sections of the White Lake soil series of which two occur around the Hamlet of Bobs Lake and along the shoreline east of Ashnelot Island. The Monteagle soil complex consists of a shallow, well-drained, non-calcareous sandy loam with frequent outcrops of crystalline bedrock while the White Lake series consists of shallow, well-drained, gravelly, sandy loam.

Bobs Lake is very irregular in shape and is composed of numerous small bays joined by narrow channels. The water surface area is 24.5 square kilometers (6,000 acres) surrounded by 198 kilometers (123 miles) of irregular shoreline. The mean depth is 7.5 meters (24.7 feet) with a maximum depth of 25.6 meters (84 feet). The Bobs Lake drainage basin, 316 square kilometers (122 square miles), forms the headwaters of the Tay River which flows via the Rideau Canal System into the St. Lawrence River terminal drainage basin. As Bobs Lake is a reservoir for the Rideau Canal System, it can experience maximum water fluctuations of up to 2.7 meters

(9 feet) when called upon to augment canal flows. The control dam which is at the lake outlet to the Tay River near Bolingbroke is owned and operated by the Federal Department of Transport and was established in 1898.

There are a number of inlets, of which the channel from Crow Lake is the major and Fish, Eagle and Sucker creeks are minor sources of inflow.

Water Usage

Most cottagers use the lake as their source of domestic water supply. Recreational uses of the lake include boating, swimming and angling. The common game fish are pickerel, largemouth and smallmouth bass.

There are no direct discharges of wastes into Bobs Lake from communal or municipal sewage treatment facilities. There does not appear to be any pollution from the operation of existing municipal solid waste disposal sites.

Shoreline Development

Road access has to a large extent determined the development pattern of the approximately 600 cottages on Bobs Lake (Figure 1). The western shore from Crow Bay to Mud Bay previously had few cottages. It is now accessible by road and development of a substantial number of additional cottages is presently underway. The remaining shoreline has the cottages evenly distributed except where the topography is unsuitable because of excessive slope or the presence of marshes.

RESULTS AND DISCUSSION

Bacteriology

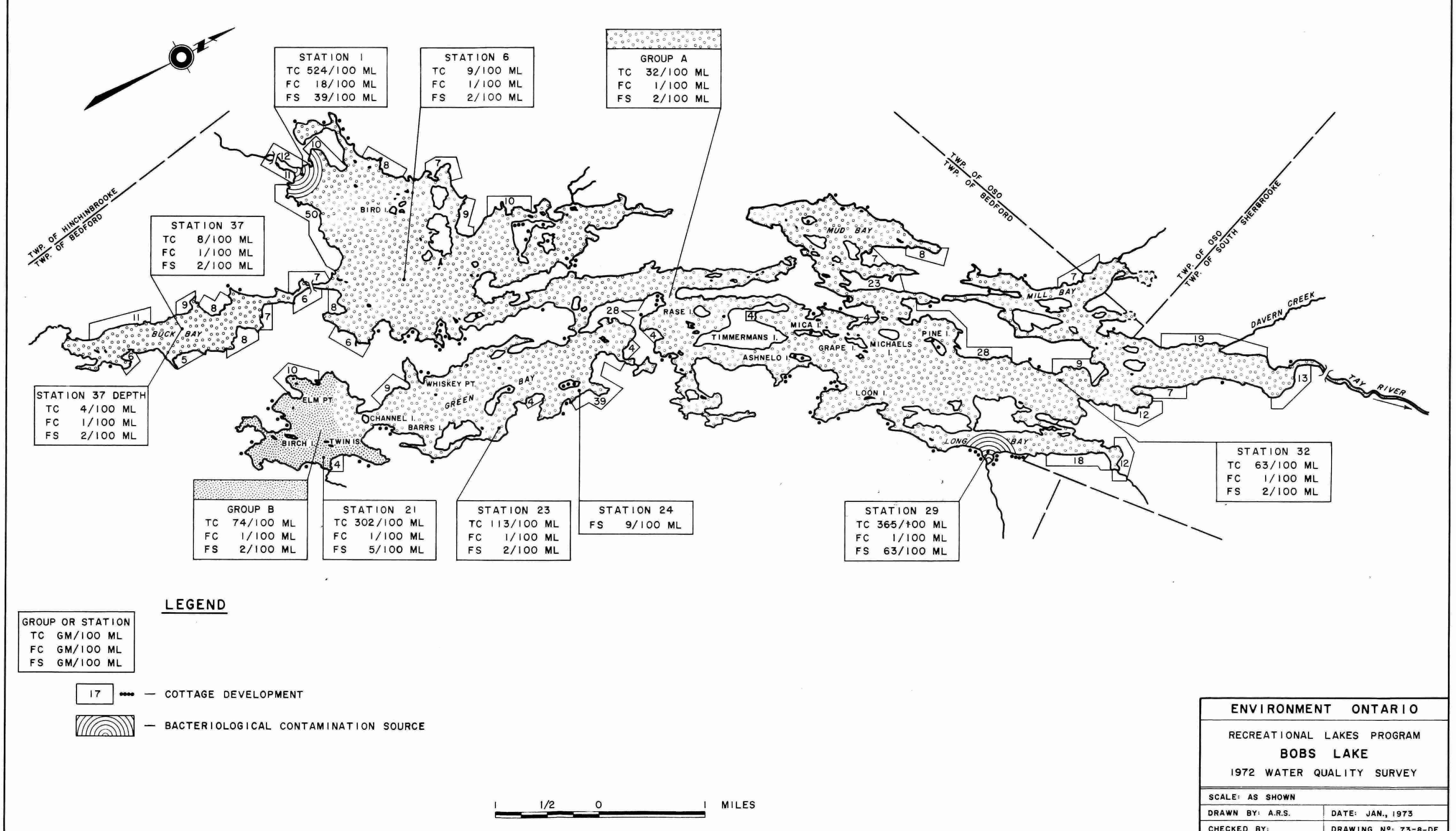
The quantities of bacteriological data necessitated statistical methods to summarize the results into a concise presentation without the inconsistency associated with manual interpretation. The methods used are based on the analysis of variance and Barlett's test of homogeneity by which stations on a lake can be grouped into areas with the same bacterial level. Areas or stations with only slight differences in bacterial concentration can be isolated. It was found on previous work that areas, or stations, with significantly higher bacterial numbers generally indicated a pollution input. Details of statistical methods and data are available on request.

Based on the data from the 1972 spring and summer surveys, Bobs Lake was, with the exception of the inflows from Fish and Thompson creeks, found acceptable and well within the Ministry of the Environment Criteria which state: "Where ingestion is probable, recreational waters can be considered impaired when the coliform (TC), fecal coliform (FC), and/or enterococcus (FS) geometric mean density exceeds 1000, 100 and/or 20 per 100 ml respectively,...". (1)

In June, Bobs Lake had an overall mean (Group A) of 32 TC/100 ml with the exception of a south eastern bay (Group B) and eight isolated stations (Figure 3). Fecal coliforms were homogeneous over the lake with a mean of 1 FC/100 ml with the exception of the outflow of Fish Creek (Station 1). Fecal streptococcus levels were homogeneous with a mean of 2 FS/100 ml with four exceptions. The mean count for FS of 39/100 ml in the outflow from Fish Creek, which exceeded the Ministry's Criteria, together with the elevated FC and TC counts, indicated that the creek was affected by bacterial inputs probably from

(1) Guidelines and Criteria for Water Quality Management in Ontario, MOE, 1973.

FIGURE 3 - DISTRIBUTION OF BACTERIA IN JUNE



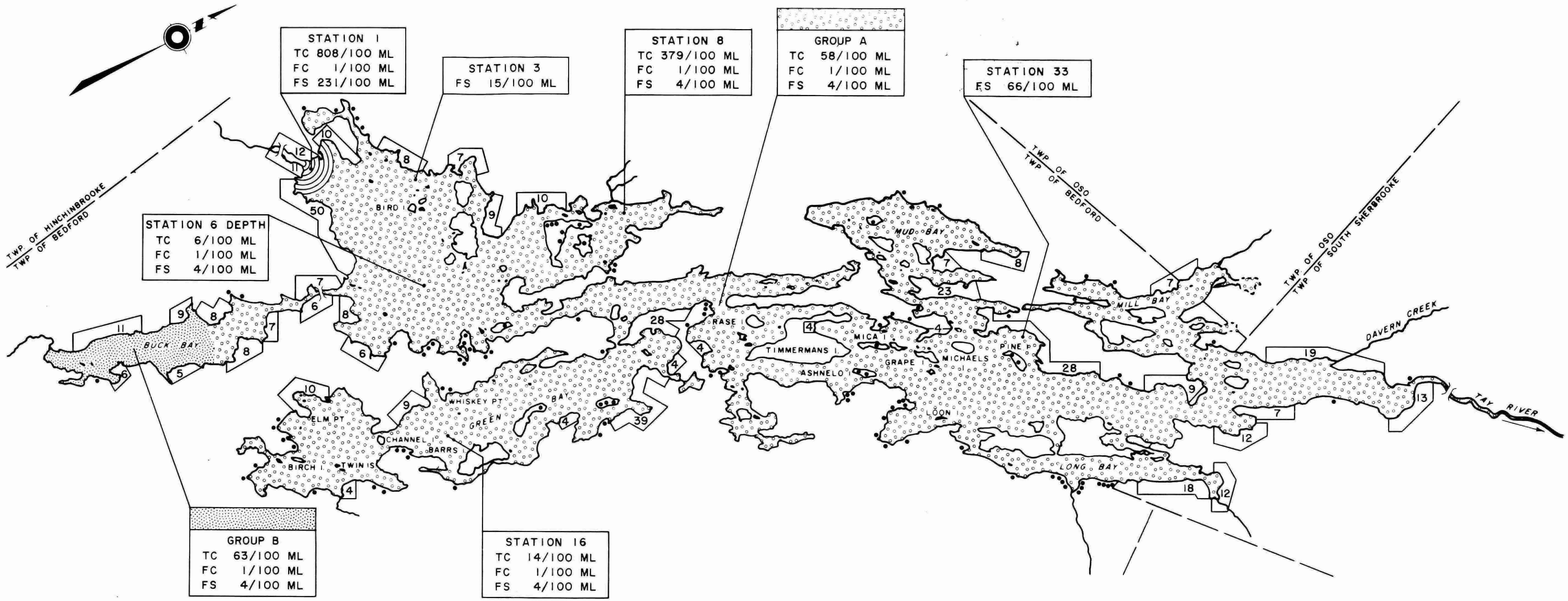
animals and from domestic wastes. Thompson Creek flowing into Long Bay also showed excessive enterococcus counts (63 FS/100 ml) indicating that it contained bacteria which probably originated from wild or domestic animals.

In July the overall total coliform level (Group A) was 58 TC/100 ml while Buck Bay (Group B) had a mean of 63 TC/100 ml. Four isolated stations displayed unique total coliform counts (Figure 4). Fecal streptococcus, with three exceptions was homogeneous with a mean of 4 FS/100 ml. The outfall of Fish Creek (Station 1) and the area between Pine Island and the north shore exceeded the Ministry's FS Criteria with respective counts of 231/100 ml and 66/100 ml but neither contained the elevated FC levels which are most characteristic of contamination by domestic sewage.

No rainfall was recorded at the Bell Rock and/or Hartington Meteorological Stations during the surveys and it may be assumed that the survey results represented dry weather conditions, which favored better bacterial water quality.

Standard Plate Count analysis was performed on five mid-lake areas (Stations 28, 11, 16, 6 and 37), during the two surveys to give indications of overall bacterial population on the lake. The geometric means of these tests over the June survey ranged from 400 to 1900/100 ml while the means for the July survey were higher and ranged from 800 to 6300/100 ml.

FIGURE 4 - DISTRIBUTION OF BACTERIA IN JULY



LEGEND

GROUP OR STATION
TC GM/100 ML
FC GM/100 ML
FS GM/100 ML

17 — COTTAGE DEVELOPMENT

— BACTERIOLOGICAL CONTAMINATION SOURCE

1/2 0 1 MILES

ENVIRONMENT ONTARIO

RECREATIONAL LAKES PROGRAM

BOBS LAKE

1972 WATER QUALITY SURVEY

SCALE AS SHOWN	
DRAWN BY A.R.S.	DATE JAN., 1973
CHECKED BY	DRAWING Nº 73-8-DE

Chemistry

The deepest points in five of the numerous deep water basins in the separate arms of Bobs Lake were selected as 'mid-lake' stations. The bottom waters at these stations became isolated from one another by July, when the level of thermal stratification (see page A-8 for explanation) in each basin descended below the bottom of the connecting channels. Stratified conditions persisted strongly at all five stations through to the September survey, (Figures 5, 6 and 7). Increasingly severe oxygen depletions coupled with decreases in pH because of an accumulation of carbon dioxide were observed in the bottom waters. This confirms that the process of bacterial decomposition of organic matter was occurring. Conditions of temperature stratification retard both the escape of the carbon dioxide formed from the dissolved oxygen by this process and the entry of fresh oxygen. By late September, as much as the bottom 12 meters of water was rendered void of oxygen, preventing fish from inhabiting these cooler deep waters.

The data obtained from these deep water stations show the process of oxygen depletion and nutrient regeneration very clearly. (Figures 5, 6, 7 and the table below). Four stations repeatedly rank themselves in the same order; by depth, and by changes in bottom temperatures, DO depletions and nutrient contents:

Most affected	-Station 37, Bucks Bay
Affected	-Station 28, North End of Bobs Lake
Less Affected	-Station 11, Central Bobs Lake
Least Affected	-Station 16, Green Bay

It is apparent of course, that the data for the fifth station, Number 6, does not fit exactly into the patterns demonstrated by the other four. Temperature

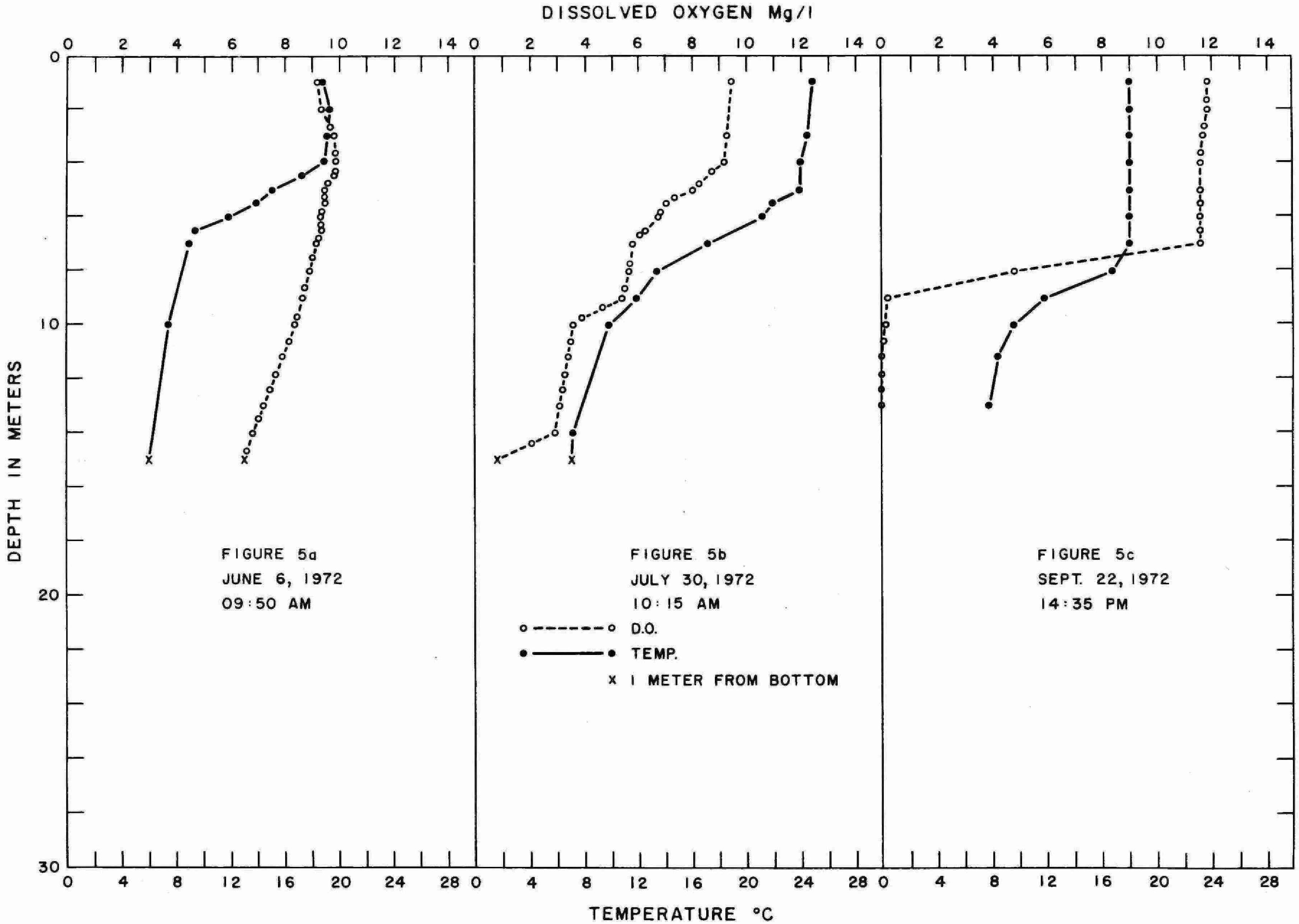


FIGURE 5 - DISSOLVED OXYGEN AND TEMPERATURE PROFILES AT STATION 37 BOBS LAKE

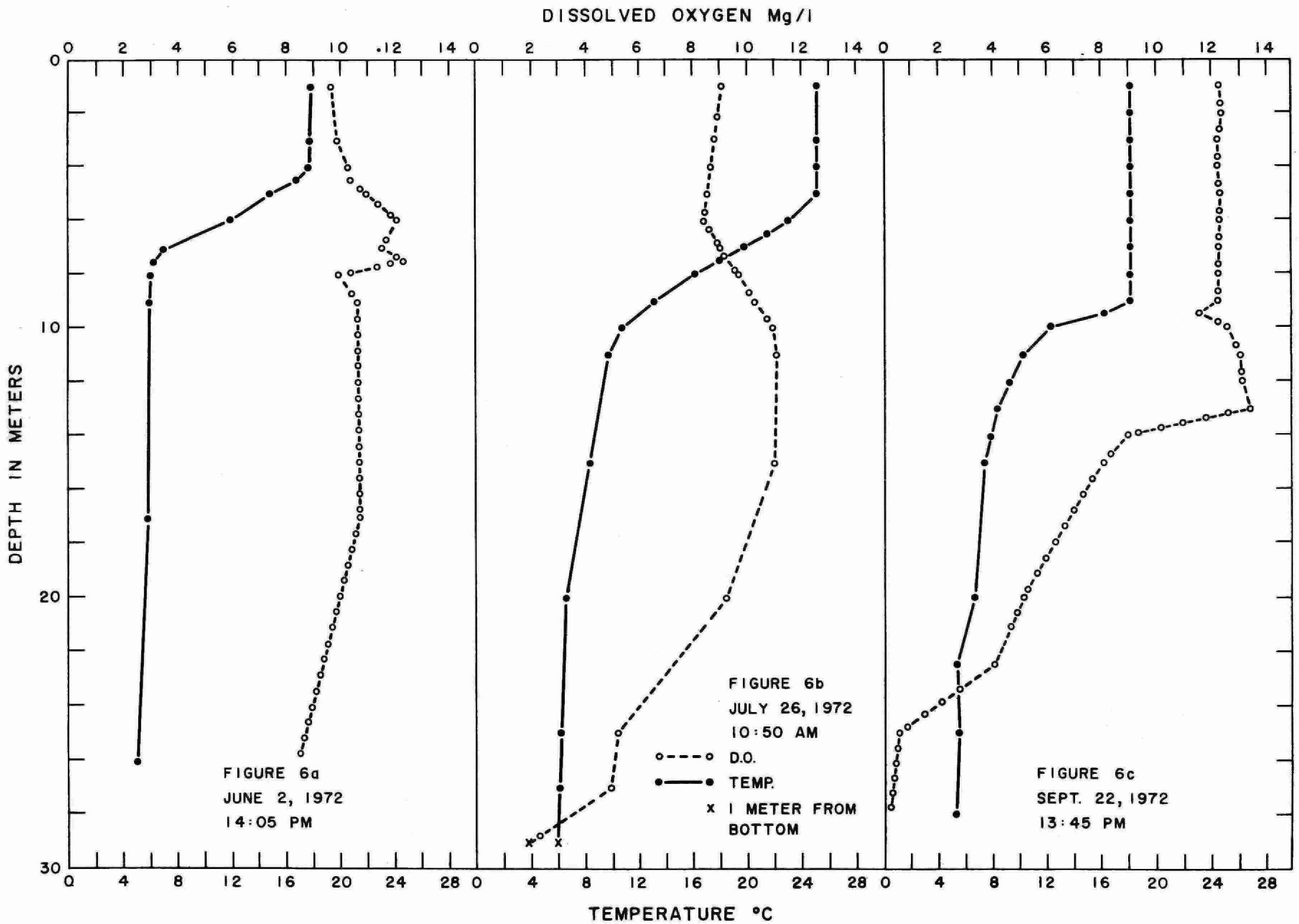


FIGURE 6 - DISSOLVED OXYGEN AND TEMPERATURE PROFILES AT STATION 16

BOBS LAKE

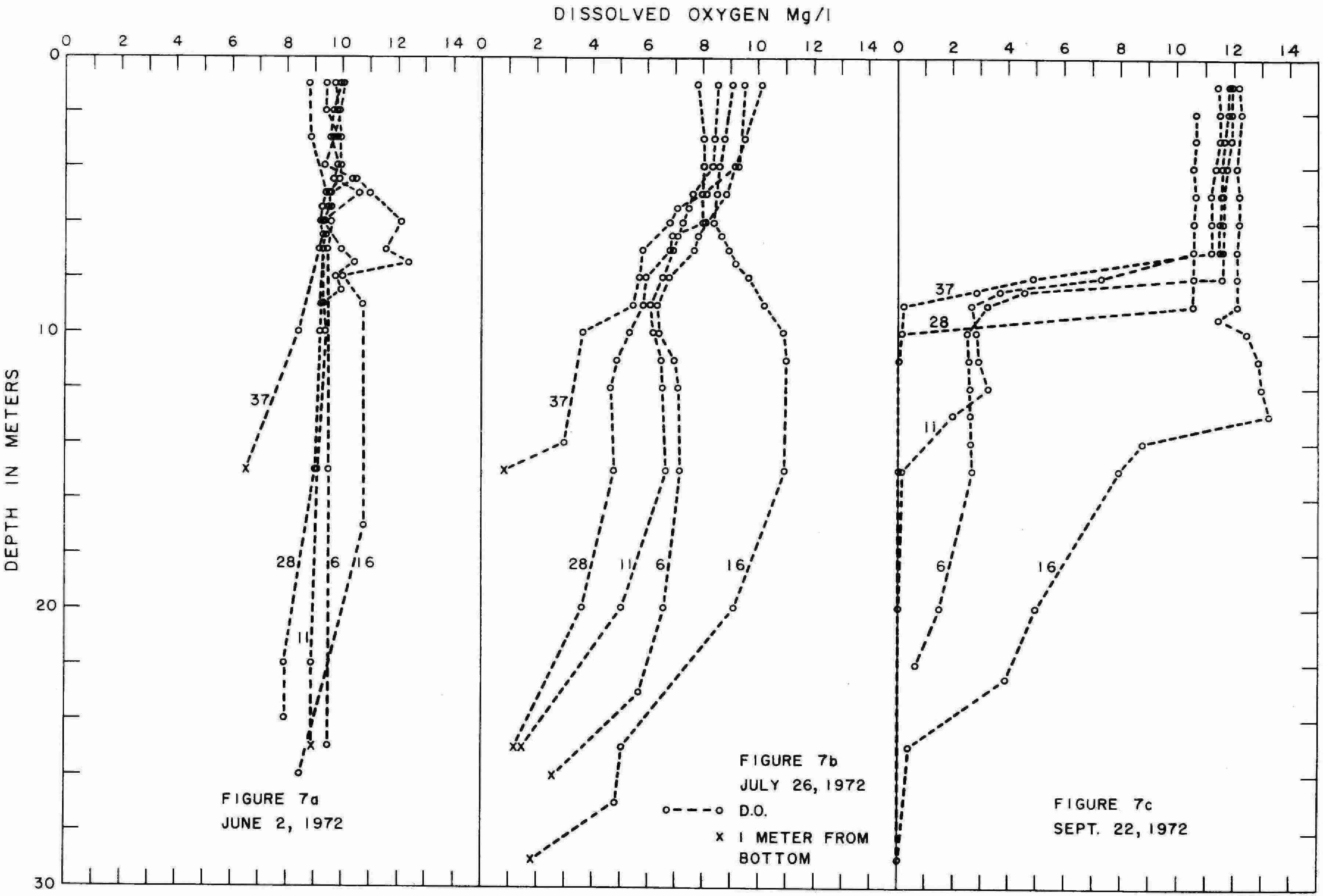


FIGURE 7 - DISSOLVED OXYGEN PROFILES
AT ALL MID LAKE STATIONS
BOBS LAKE

and depth values place Station 6 midway in the station order, but the DO and nutrient data are irregular, calling for a placement anywhere from third worst to best in the sequence of stations.

Through the periods of sampling from June to September the four stations, while maintaining their ranking, showed progressive deterioration which was worse in the shallower of the basins, where bottom temperatures were higher.

The process of deterioration appears to follow these general steps: -

1. Gradual and complete loss of dissolved oxygen from the deep water, occurring most rapidly adjacent to the bottom sediments. This was greater in intensity and extent in proportion to shallowness, as would be expected, since the deeper waters have greater reserves of DO with which to withstand oxygen demands.

2. Regeneration of phosphorus compounds, and of nitrogen compounds (organic, nitrate, nitrite and ammonia) from the sediments, or from settling organic debris. This can cause cumulative nutrient recycling (see page A-9). In the following table, the stations have been listed in order according to the amount of total phosphorus regenerated by September. The amounts of total nitrogen regenerated follow the same order, almost exactly, and both values show this increase in proporation to bottom temperatures. This is reasonable, since increased temperature generally speeds up bacterial, biological and chemical processes, and may induce a greater accumulation of their intermediate and end products.

BOBS LAKE

Bottom Samples
Survey Averages
ug/l

	June	July	Sept.
Station 37 - Bucks Bay,			
Av. Temp. - 6.9°C, Depth - 17 Meters			
Total Phosphorus, as P	22	71	120
Total Nitrogen, as N	470	680	825
Nitrate + Nitrite, as N	59	185	36
Ammonia, as N	50	45	190
Iron, as Fe	80	520	480
Station 28 - North end of Bobs Lake,			
Av. Temp. - 6.3°C, Depth - 24.7 Meters			
Total Phosphorus, as P	56	96	103
Total Nitrogen, as N	490	660	850
Nitrate + Nitrite, as N	44	220	215
Ammonia, as N	25	25	90
Station 11 - Central Bobs Lake,			
Av. Temp. - 5.0°C, Depth - 25.2 Meters			
Total Phosphorus, as P	36	76	66
Total Nitrogen, as N	450	680	695
Nitrate + Nitrite, as N	66	310	235
Ammonia, as N	<10	20	55
Station 16 - Green Bay,			
Av. Temp. - 4.8°C, Depth - 29.4 Meters			
Total Phosphorus, as P	23	30	56
Total Nitrogen, as N	390	450	595
Nitrate + Nitrite, as N	23	100	95
Ammonia, as N	20	30	80
Station 6, South end of Bobs Lake,			
Av. Temp. - 5.6°C, Depth - 24.8 Meters			
Total Phosphorus, as P	23	30	36
Total Nitrogen, as N	440	495	630
Nitrate + Nitrite, as N	66	135	215
Ammonia, as N	15	<10	15

3. Bacterial conversion of nitrogen compounds containing oxygen (nitrate, nitrite) to those which do not (ammonia, amines), in order to utilize the oxygen so recovered. This is particularly evident at Station 37, and is generally indicative of a more advanced stage of deterioration, than when substantial amounts of nitrate are still present, as at the other stations.

4. Regeneration of minerals such as iron. Station 37 was the only sampling point to reach this stage.

While much of the nutrient and organic materials which are present in Bobs Lake are likely to have been derived from natural sources (such as the input from Fish Creek, below) the sequences involved in their decomposition and regeneration coincide generally with those observed in the initial stages of the decomposition of domestic sewage or food wastes.

5. A further step, not observed in these samples, would be the conversion of sulphate (SO_4) to sulphides such as H_2S, in order to utilize the oxygen so recovered. If sulphides are produced they are part of the cause of the stench observed in waters most severely affected by anaerobic conditions.

The mineral contents of the inflows to the south end of Bobs Lake were all low with values in the ranges quoted below, with the exception of a chloride content of 6 mg/l at Station 39 and of 2 mg/l at Station 37. All these waters were soft, with a hardness slightly less than half the value characteristic of the waters of the Lower Great Lakes, and reflect the insoluble nature of the hard rock and soil of the areas drained by these tributaries.

Samples at Station 6 in the south end of Bobs Lake had slightly lower values, probably a residual effect of the more dilute flows which would have accumulated

in this basin during the spring runoff, prior to the beginning of sampling. The values at Station 11 in central Bobs Lake show an increase in minerals due to the effect of the relatively hard water entering from Green Bay (Stations 21 and 16). The soils in the areas draining to Green Bay are thus indicated to contain a greater proportion of soluble limestone than elsewhere around the lake. The northern end of Bobs Lake and the Tay River outflow remained at substantially the same mineral content as at Station 11, despite the entry of a slightly harder water at Station 29.

Mineral Content
Overall Study Averages

	Conductivity micromhos per cm^3	Alkalinity as $CaCO_3$ mg/l	Hardness as $CaCO_3$ mg/l	Chlorides as Cl mg/l
Station 6	129	48	62	3.
Station 21	219	95	116	3.
Station 16	196	83	98	3.
Range among all other stations - 1, 8, 11, 28 35, 37 and 39	132-141	50-58	64-72	3-3.5 (except at 39 and 37)

The surface samples from the 'mid-lake' stations and all but one of the inflows contained moderate concentrations of nutrients and a low iron content. Samples from the inflow of Fish Creek at Station 1 showed consistently high values, and since this creek drains a substantial watershed, it was a considerable source of nutrient and iron input to the lake.

Station 1 - Fish Creek inflow, south end of Bobs Lake

Total Phosphorus as P, mean	-	43 ug/l
Total Kjeldahl Nitrogen, mean	-	730 ug/l
Total Iron as Fe, mean	-	290 ug/l

Chlorophyll a values in the inflows were low, as is expected in flowing waters which normally have a low algal content, with overall survey averages ranging from 1.5 to 2.8 ug/l. Chlorophyll a in samples collected from the photic zone at the 'mid-lake' stations correlated with the total phosphorus content on the basis of overall survey averages, as listed below, suggesting that the phosphorus level may have been controlling algae production.

Mid-lake Stations
Photic Zone Samples
Overall Study Averages

	Total Phosphorus as P ug/l	Chlorophyll a ug/l	Secchi Disc, Meters
Station 6 - South end of Bobs Lake	24	4.2	3.5
Station 28 - North end of Bobs Lake	21	3.7	4.1
Station 11 - Central Bobs Lake	20	3.5	3.6
Station 37 - Bucks Bay	18	2.8	3.9
Station 16 - Green Bay	15	2.2	4.9

This overall correlation was reinforced by the Secchi Disc data, which generally showed an increase in transparency from station to station in the same sequence as for the decreases in phosphorus and in chlorophyll a.

The total phosphorus in surface samples declined at four of these stations between the June and July surveys. These declines were also accompanied by proportional drops in chlorophyll a, hence in algae, but for further reductions in phosphorus by September, this relationship did not continue to hold. It was not, however, sufficiently divergent as to affect the overall average relation above.

Secchi Disc and Chlorophyll a Correlation

On a scale of lake enrichment as indicated by chlorophyll a concentrations and water transparency (Figure 8), the various basins of Bobs Lake are shown to range about the positions occupied by Balsam and Cameron lakes, two relatively clear water lakes, and are far removed from such highly enriched waters as the Western Basin of Lake Erie, Lake Scugog and the Bay of Quinte.

In sum, the phosphorus, chlorophyll a and transparency values indicate a range of fertility from low in Green Bay, to moderate in the south end of Bobs Lake.

It should be noted, however, that in each of the basins of Bobs Lake which were sampled, up to 12 meters of deep water was devoid of oxygen for a substantial period prior to, and probably following the September survey, rendering these depths uninhabitable by fish. Thus, there is a need to prevent the discharge of organic wastes and nutrients to Bobs Lake. Additional nutrients could sponsor further algal and aquatic plant growth, and thereby additional decomposition of such material once it settled to the bottom, and are likely to accentuate the problems of oxygen depletion in the deep waters of Bobs Lake. Nutrient recycling would magnify the adverse effects. Cottagers should ensure that their waste disposal facilities are functioning properly in order to prevent seepage of such nutrients to the lake.

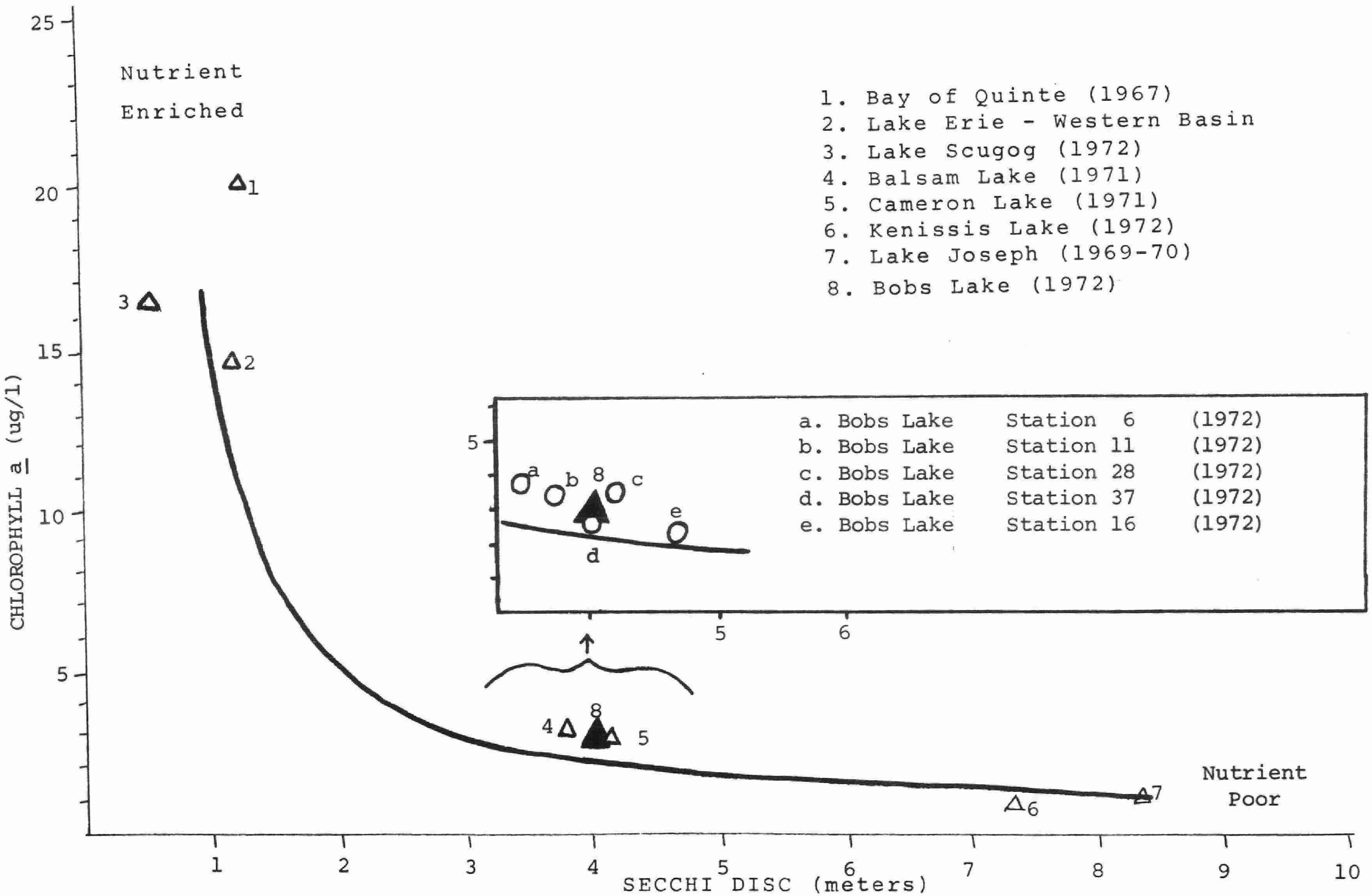


Figure 8: The mean of chlorophyll a and Secchi disc measurements in Bobs Lake relative to a curve describing the chlorophyll a - Secchi disc relationship in many Ontario lakes. Seven other well known lakes are included for comparison with Bobs Lake.

INFORMATION OF GENERAL INTEREST TO COTTAGERS
MICROBIOLOGY OF WATER

For the sake of simplicity, the microorganisms in water can be divided into two groups: the bacteria that thrive in the lake environment and make up the natural bacterial flora; and the disease causing microorganisms, called pathogens, that have acquired the capacity to infect human tissues.

The "pathogens" are generally introduced to the aquatic environment by raw or inadequately treated sewage, although a few are found naturally in the soil. The presence of these bacteria do not change the appearance of the water but pose an immediate public health hazard if the water is used for drinking or swimming. The health hazard does not necessarily mean that the water user will contract serious waterborn infections such as typhoid fever, polio or hepatitis but he may catch lesser infections of gastroenterities (sometimes called stomach flu), dysentery or diarrhea. Included in these minor afflictions are eye, ear and throat infections that swimmers encounter every year and the more insidious but seldom diagnosed, subclinical infections usually associated with several water born viruses. These virus infections leave a person not feeling well enough to enjoy holidaying although not bedridden. This type of microbial pollution can be remedied by preventing wastes from reaching the lake and water quality will return to satisfactory conditions within a relatively short time (approximately 1 year) since disease causing bacteria usually do not thrive in an aquatic environment.

The rest of the bacteria live and thrive within the lake environment. These organisms are the instruments of biodegradation. Any organic matter in the lake will be used as food by these organisms and will be used as food

by these organisms and will give rise, in turn, to subsequent increases in their numbers. Natural organic matter as well as that from sewage, kitchen wastes, oil and gasoline are readily attached by these lake bacteria. Unfortunately, biodegradation of the organic wastes by organisms uses correspondingly large amount of the dissolved oxygen. If the organic matter content of the lake gets high enough, these bacteria will deplete the dissolved oxygen supply in the bottom waters and threaten the survival of many deep water fish species.

The standard plate count (SPC) populations given in the text supply an indication of the number of these bacteria in the lake.

RAINFALL AND BACTERIA

The "Rainfall Effect" referred to in the text, relates to a phenomena that has been documented in previous surveys of the Recreational Lakes. Heavy precipitation has been shown to flush the land area arrund the lake and the subsequent runoff will carry available contaminants including sewage organisms as well as natural soil bacteria with it into the water.

Total coliforms, fecal coliforms and fecal streptococci, as well as other bacteria and viruses which inhabit human waste disposal systems can be washed into the lake. In Precambrian areas where there is inadequate soil cover and in fractured limestone areas where fissures in the rocks provide access to the lake, this phenomenon is particularly evident.

Melting snow provides the same transportation function for bacteria, especially in an agricultural area where manure spreading is carried out in the winter on top of the snow.

Previous data from sampling points situated 50 to 100 feet from shore indicate that contamination from shore generally shows up within 12 to 48 hours after a heavy rainfall.

WATER TREATMENT

Lake and river water is open to contamination by man, animals and birds (all of which can be carriers of disease); consequently, NO SURFACE WATER MAY BE CONSIDERED SAFE FOR HUMAN CONSUMPTION without prior treatment, including disinfection. Disinfection is especially critical if coliforms have been shown to be present.

Disinfection can be achieved by:

(a) Boiling

B oil the water for a minimum of five minutes to destroy the disease causing organisms.

(b) Chlorination Using a Household Bleach Containing 4 to 5.1/4% Available Chlorine

Eight drops of a household bleach solution should be mixed with one gallon of water and allowed to stand for 15 minutes before drinking.

(c) Continuous Chlorination

For continuous water disinfection, a small domestic hypochlorinator (sometime coupled with activated charcoal filters) can be obtained from a local plumber or water equipment supplier.

(d) Well Water Treatment

Well water can be disinfected using a household bleach (assuming

strength at 5% available chlorine) if the depth of water and diameter of the well are known.

CHLORINE BLEACH
per 10 ft depth of water

Diameter of Well Casing In Inches	One to Ten Coliforms	More than Ten Coliforms
4	.5 oz	1 oz.
6	1 oz.	2 oz.
8	2 oz.	4 oz.
12	4 oz.	8 oz.
16	7 oz.	14 oz.
20	11 oz.	22 oz.
24	16 oz.	31 oz.
30	25 oz.	49 oz.
36	35 oz.	70 oz.

Allow about six hours of contact time before using the water.

Another bacteriological sample should be taken after one week of use.

Water Sources (spring, lake, well, etc.) should be inspected for possible contamination routes (surface soil, runoff following rain and seepage from domestic waste disposal sites). Attempts at disinfecting the water alone without removing the source of contamination will not supply bacteriologically safe water on a continuing basis.

There are several types of low cost filters (ceramic, paper, carbon, diatomaceous earth sometimes impregnated with silver, etc.) that can be easily installed on taps or in water lines. These may be useful to remove particles if water is periodically turbid and are usually very successful. Filters, however, do not disinfect water but may reduce bacterial numbers. For safety, chlorination of filtered water is recommended.

SEPTIC TANK INSTALLATIONS

In Ontario, provincial law requires that you obtain permission in writing to install a septic tank system. Permission can be obtained from the local Medical Officer of Health or in some instances from the Regional Engineer of the Ministry of the Environment. Any other pertinent information such as sizes, types and location of septic tanks and tile fields can also be obtained from the same authority.

(i) General Guidelines

A septic tank should not be closer than:

-50 feet to any well, lake, stream or pond.
-5 feet to any building.
-10 feet to any property boundary

The tile field should not be closer than:

-100 feet to the nearest dug well.
-50 feet to a drilled well which has a casing to 25 feet below ground.
-25 feet to a building
-10 feet to a property boundary.
-50 feet to any lake, stream or pond.

The ideal location for a tile field is in a well drained, sandy loam soil remote from any wells or other drinking water sources. For the tile field to work satisfactorily, there should be at least 3 feet of soil between the bottom of the weeping tile trenches and the top of the ground water table or bedrock.

DYE TESTING OF SEPTIC TANK SYSTEMS

There is considerable interest among cottage owners to dye test their sewage systems, however, several problems are associated with dye testing. Dye would not be visible to the eye from a system that has a fairly direct

connection to the lake. Thus, if a cottager dye-tested his system and no dye was visible in the lake, he would assume that his system is satisfactory, which might not be the case. A low concentration of dye is not visible and therefore expensive equipment such as a fluorometer is required. Only qualified people with adequate equipment are capable of assessing a sewage system by using dye. In any case, it is likely that some of the water from a septic tank will eventually reach the lake. The important question is whether all contaminants including nutrients have been removed before it reaches the lake. To answer this question special knowledge of the system, soil depth and composition, underground geology of the region and the shape and flow of the shifting water table are required. Therefore, we recommend that this type of study should be performed only by qualified professionals.

BOATING REGULATION

In order to help protect the lakes and rivers of Ontario from pollution it is required by law that sewage (including garbage) from all pleasure craft, including houseboats must be retained in equipment of a type approved by the Ministry of the Environment. Equipment which will be approved by the Ministry of the Environment includes (1) retention devices with or without circulation which retain all toilet wastes for disposal ashore, and (2) incinerating devices which reduce all sewage to ash.

To be approved, equipment shall:

1. be non-portable,
2. be constructed of structurally sound material,
3. have adequate capacity for expected use
4. be properly installed,

5. in the case of storage devices, be equipped with the necessary pipes and fittings conveniently located for pump-out by shore-based facilities (although not specified, a pump-out deck fitting with 1.1/2 inch National Pipe Thread is commonly used).

An Ontario regulation requires that marinas and yacht clubs provide or arrange pump-out service for the customers and members who have toilet-equipped boats. In addition, all marinas and yacht clubs must provide litter containers that can be conveniently used by occupants of pleasure boats.

The following "Tips" may be of assistance to you in regards to boating:

1. Motors should be in good mechanical condition and properly tuned.

2. When a tank for outboard motor testing is used, the contents should not be emptied into the water.

3. Fuel hoses must be in good condition and all connections tight.

4. If the bilge is cleaned prior to the boating season, the waste material must not be dumped into the water.

5. Fuel tanks must not be overfilled and space must be left for expansion if the fuel warms up.

6. Vent pipes should not be obstructed and fuel needs to be dispensed at a correct rate to prevent "blow-back".

7. Empty oil cans must be deposited in a leak-proof receptacle.

ICE-ORIENTED RECREATIONAL ACTIVITIES

The Ministry of the Environment is presently preparing regulations to control pollution from ice-oriented recreational activities. In past years, there has been indiscrimate dumping of garbage and sewage on the ice. The bottoms of fish huts have been left on the ice and become a navigational hazard to boaters in the spring. Broken glass has been left on the ice only to become

injurious to swimmers. With the anticipated introduction of the regulations, many of these abuses will become illegal.

EUTROPHICATION OR EXCESSIVE FERTILIZATION AND LAKE PROCESSES

The changes in water quality brought about by excessive inputs of nutrients to lakes are usually evidenced by excessive growths of algae and aquatic plants.

Aquatic plants and algae are important in maintaining a balanced aquatic environment. They provide food and a suitable environment for the growth of aquatic invertebrate organisms which serve as food for fish. Shade from large aquatic plants helps to keep the lower water cool which is essential to certain species of fish and also provide protection for young game and forage fish. Numerous aquatic plants are utilized for food and/or protection by many species of waterfowl. However, too much growth creates an imbalance in the natural plant and animal community particularly with respect to oxygen conditions, and some desirable forms of life such as sport fish are eliminated and unsightly algae scums can form. The lake will not be "dead" but rather abound with life which unfortunately is not considered aesthetically pleasing. This change to poor water quality becomes apparent after a period of years in which extra nutrients are added to the lake and a return to the natural state may also take a number of years after the nutrient inputs are stopped. Changes in water quality with depth are a very important characteristic of a lake. Water temperatures are uniform throughout the lake in the early spring and winds generally keep the entire volume well mixed. Shallow lakes may remain well mixed all summer so that water quality will be the same throughout. On the other hand, in deep lakes, the surface waters

warm up during late spring and early summer and float on the cooler more dense water below. The difference in density offers a resistance to mixing by wind action and many lakes do not become fully mixed again until the surface waters cool down in the fall. The bottom water receives no oxygen from the atmosphere during this unmixed period and the dissolved oxygen supply may be all used up by bacteria as they decompose organic matter. Cold water fish, such as trout, will have to move to the warm surface waters to get oxygen and because of the high water temperatures they will not thrive, so that the species will probably die out (see Figure next page).

Low oxygen conditions in the bottom waters are not necessarily an indication of pollution but excessive aquatic plant and algae growth and subsequent decomposition can aggravate the condition and in some cases can result in zero oxygen levels in lakes which had previously held some oxygen in the bottom waters all summer. Although plant nutrients normally accumulate in the bottom waters of lakes, they do so to a much greater extent if there is no oxygen present. These nutrients become available for algae in the surface waters when the lake mixes in the fall and dense algae growths can result. Consequently, lakes which have no oxygen in the bottom water during the summer are more prone to having algae problems and are more vulnerable to nutrient inputs than lakes which retain some oxygen.

CONTROL OF AQUATIC PLANTS AND ALGAE

Usually aquatic weed growths are heaviest in shallow shoreline areas where adequate light and nutrient conditions prevail.

Extensive aquatic plant and algal growths sometimes interfere with

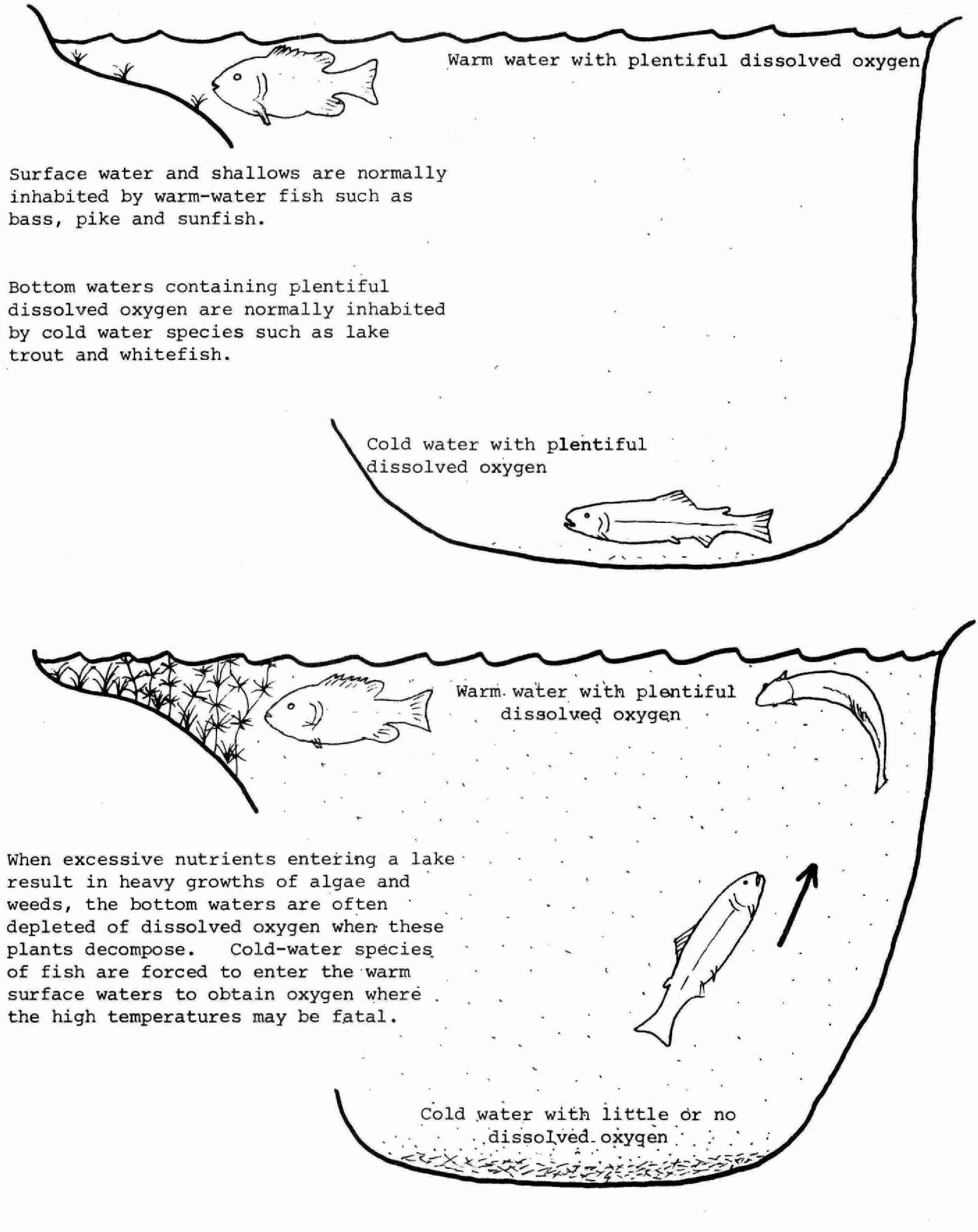


FIGURE A-1: DECOMPOSITION OF PLANT MATTER AT THE LAKE BOTTOM CAN LEAD TO DEATH OF DEEP-WATER FISH SPECIES.

boating and swimming and ultimately diminish shoreline property values.

Control of aquatic plants may be achieved by either chemical or mechanical means. Chemical methods of control are currently the most practical, considering the ease with which they are applied. However, the herbicides and algicides currently available generally provide control for only a single season. It is important to ensure that an algicide or herbicide which kills the plants causing the nuisance, does not affect fish or other aquatic life and should be reasonable in cost. At the present time, there is no one chemical which will adequately control all species of algae and other aquatic plants. Chemical control in the province is regulated by the Ministry of the Environment and a permit must be granted prior to any operation. Simple raking and chain dragging operations to control submergent species have been successfully employed in a number of situations; however, the plants soon re-establish themselves. Removal of weeds by underwater mowing techniques is certainly the most attractive method of control and is currently being evaluated in Chemung Lake near Peterborough. Guidelines and summaries of control methods, and applications for permits are available from the Biology Section, Water Quality Branch, Ministry of the Environment, Box 213, Rexdale, Ontario.

PHOSPHORUS AND DETERGENTS

Scientists have recognized that phosphorus is the key nutrient in stimulating algal and plant growth in lakes and streams.

In the past years, approximately 50% of the phosphorus contributed by municipal sewage was added by detergents. Federal regulations reduced

the phosphate content as P_2O_5 in laundry detergents from approximately 50% to 20% on August 1, 1970 and to 5% on January 1, 1973.

It should be recognized that automatic dishwashing compounds were not subject to the recently approved government regulations and that surprisingly high numbers of automatic dishwashers are present in resort areas (a questionnaire indicated that about 30% of the cottages in the Muskoka Lakes have automatic dishwashers). Cottagers utilizing such conveniences may be contributing significant amounts of phosphorus to recreational lakes. Indeed, in most of Ontario's vacation land, the source of domestic water is soft enough to allow the exclusive use of liquid dishwashing compounds, soap and soap-flakes.

ONTARIO'S PHOSPHORUS REMOVAL PROGRAM

By 1975, the Government of Ontario expects to have controls in operation at more than 200 municipal wastewater treatment plants across the province serving some 4.7 million persons. This represents about 90% of the population serviced with sewers. The program is in response to the International Joint Commission recommendations as embodied in the Great Lakes Water Quality Agreement and studies carried out by the Ministry of the Environment on inland recreational waters which showed phosphorus to be a major factor influencing eutrophication. The program makes provision for nutrient control in the Upper and Lower Great Lakes, the Ottawa River system and in prime recreational waters where the need is demonstrated or where emphasis is placed upon prevention of localized eutrophication.

Phosphorus removal facilities must be operational at wastewater treatment plants by December 31, 1973, in the most critically affected areas

of the province, including all of the plants in the Lake Erie drainage basin and the inland recreational areas. The operational date for plants discharging to waters deemed to be in less critical condition which includes plants larger than one million gallons per day (1 mgd) discharging to Lake Ontario and to the Ottawa River system, is December 31, 1975. The 1973 phase of the program will involve 156 plants of which 85 are in the Lake Erie basin and another 30 in the Lake Huron drainage basin. The capacities of these plants range from 0.04 to 24.0 mgd, serving an estimated population of 1,600,000 persons. The 1975 phase will bring into operation another 57 plants ranging in size from 0.3 to 180 mgd serving an additional 3,100,000 persons. Treatment facilities utilizing the Lower Great Lakes must meet effluent guidelines of less than 1.0 milligrams per litre of total phosphorus in their final effluent. Facilities utilizing the Upper Great Lakes, the Ottawa River Basin and certain areas of Georgian Bay where needs have been demonstrated must remove at least 80% of the phosphorus reaching their sewage treatment plants.

CONTROL OF BITING INSECTS

Mosquitoes and blackflies often interfere with the enjoyment of recreational facilities at the lake-side vacation property. Pesticidal spraying or fogging in the vicinity of cottages produces extemely temporary benefits and usually do not justify the hazard involved in contaminating the nearby water. Eradication of biting fly populations is not possible under any circumstances and significant control is rarely achieved in the absence of large-scale abatement programmes involving substantial funds and trained personnel. Limited use of approved

larvicides in small areas of swamp or in rain pools close to residences on private property may be undertaken by individual landowners, but permits are necessary wherever treated waters may contaminate adjacent streams or lakes. The use of repellents and light traps is encouraged as are attempts to reduce mosquito larval habitat by improving land drainage. Applications for permits to apply insecticides as well as technical advice can be obtained from the Biology Section, Water Quality Branch of the Ministry of the Environment, Box 213, Rexdale, Ontario.